Single-frequency Q-switched Nd:YAG Micro-laser with 1.7-ns, 1.6-mJ Pulses at 1 kHz

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In the recent years a significant amount of effortsare focused on the development of single-frequency nanosecond and sub-nscompact lasers providing high energy (>1 mJ) and high average power(>1W) simultaneously. Q-switched, single frequency and singletransversemode lasers are essential for wide variety of applications [1] such as laser-induced breakdown spectroscopy, LIDARs, optical communications and laser trapping or cooling. The spatial dimension of conventional solid state Q-switched lasers precludes producing single frequencypulses with sub-nanosecondor few-ns duration. Although the short-cavity, passively Q-switched microchip lasers allow oscillations in single longitudinal- mode and generation of ~1 ns pulses devices their applicability is limited due to the inherent non-saturated losses in the absorber, which impose considerable limitation over achieving average power levels (~100mW) and poor ability for synchronization of the laser pulses with external electrical signals[1]. Micro lasers with active Q-switching overcome easily the intra-cavity losses and time jitter issue in the laser synchronization. However, the introduction of an active modulator leads to increase of the optical length of the cavity and therefore obtaining single frequency operation is more difficult and requires a different approach[2]. Consequently, a laser generating ~1-nanosecond, single frequency, TEM_{00}, milli-joule pulses with kHz repetition rate and high average power (≥ 1W) is at high demand.

Here we present high average power an electro-optically Q-switched micro Nd:YAG laser with self-injection seeding, providing single-frequency 1.7 ns output pulses at 1064-nm, with 1.6 mJ, and 1 kHz repetition rate.

The laser crystal is 7-mm long, 1 at.% doped Nd:YAG and effective absorption of 90 % at 808 nm. It is longitudinally pumped through the rear mirror by a fiber coupled quasi-CW diode laser.Laser cavity is a V-shapedwith a thin-film polarizer that serves as a polarization-dependent output. The TEM_{00} operation at high pump powers was ensuredby choosing a plano-convex resonator geometry. For polarization control, RTP Pockels cell (PC) was used. In order to achieve a single frequency operation, a method for self-seeding with prelease stabilization was implemented. An optical negative feedback is introduced that includes a photodiode on which 4% of the output is reflected by a glass plate. The signal from the photodiode is fed back to the PC via a high voltage driver, effectively increasing the loss of the cavity when the intensity of the beam increases.

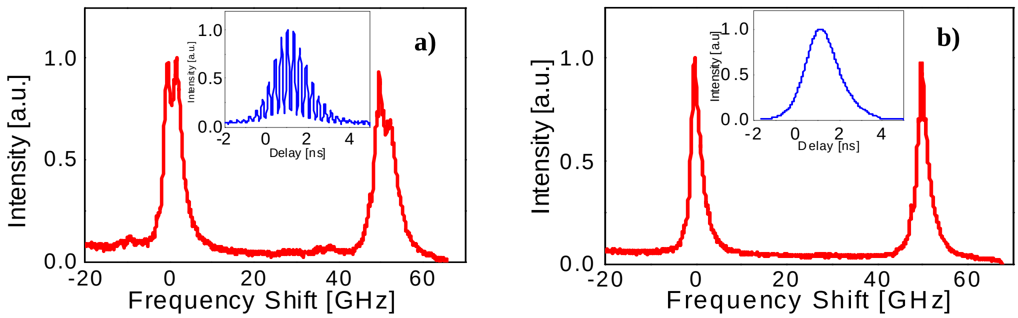

Fig. 4.Interferogram and temporal pulse shape (inset): a) without optical feedback; b) with optical feedback.

The lasing starts at pump energy of 4.8 mJ with 21% slope efficiency. When pumped with 12.2 mJ energy per pulse at 1 kHz repetition rate, the output was 1.6 mJ with nearly-diffraction limited beam (M^2= 1.05x1.02)and pulse durationof 1.7 ns (FWHM). Without preleasing and optical feedback turned off, a multi-longitudinal mode operation is observed (Fig.1a)manifested in strong modulation in the pulse temporal shape (Fig.1a) inset). Once thenegative feedback is turned on, a smooth pulse profile without high frequency modulationis obtained (see fig.1b).The interferograms on Fig. 1 a) and b) were observed with a Fabry–Pérot interferometer with spectral enough resolution to detect the 2.5-GHz shift between the neighboring cavity modes.

In conclusion an electro-optical modulator is used to obtain self-seeding , single frequency 1.7-ns , 1.6 mJ pulses at 1 kHz repetition ratewith 470 ps pulse-to-trigger timing jitter.

References

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978-1-4673-7475-0/15/$31.00 ©2015 European Union